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ABSTRACT

Assessing higher cerebral functions in patients with known or suspected dementia requires sampling numerous abilities quickly and accurately. This paper reports on the performance of 20 patients with probable dementia of the Alzheimer's type (DAT) on the BNI Screen for Higher Cerebral Functions (BNI Screen). These patients' performances were compared to the results of 20 age-matched normal control subjects. The performance of the Alzheimer's patients was consistently impaired when correlated to control subjects, as measured by both the BNI Screen total and the subtest scores. The BNI Screen total score matched significantly with the Mini Mental State Examination (MMSE) score in Alzheimer's patients, but the correlation accounted for only about 30 percent of the variance. In a brief and reliable manner, the BNI Screen appears to sample higher cerebral functions not captured by the MMSE. It also offers useful qualitat and quantitative information in assessing Alzheimer's patients. It provides both a single total score and subtest scores, the latter of which evaluate language function, visuospatial functions, facial affect perception, and the ability to generate affect in one's tone of voice. Memory and awareness scores are likewise furnished. The data provide potential clinical guidelines in assessing older individuals suspected of Alzheimer's disease. (RJM)

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Assessment of Alzheimer's Patients with the BNI Screen for Higher Cerebral Functions

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Key Words:
Alzheimer's disease
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Abstract

The performance of 20 patients with probable dementia of the Alzheimer's type (DAT) on the BNI Screen for Higher Cerebral Functions (BNI Screen) was compared to that of 20 age-matched normal control subjects. The performance of the Alzheimer's patients was consistently impaired compared to control subjects as measured by both the BNI Screen total and subtest scores. The BNI Screen total score correlated significantly with the Mini Mental State Examination (MMSE) score in Alzheimer's patients, but the correlation accounted for only about 30% of the variance. In a brief and reliable manner, the BNI Screen appears to sample higher cerebral functions not captured by the MMSE. It also provides useful qualitative and quantitative information in assessing Alzheimer's patients.

Introduction

The assessment of higher cerebral functions in patients with known or suspected dementia requires sampling numerous abilities quickly and with clinical accuracy.[17] Although disorders of memory and orientation to time and place are most common in these patients, they exhibit a variety of deficits.[2,4,6,10,12,16] Salmon and Butters[15] have therefore suggested that measures of attention, memory, abstract reasoning, problem solving, language, and constructional and visuospatial abilities as well as brief tests of "mental status" be included in the assessment of dementia in the elderly.

The BNI Screen for Higher Cerebral Functions (BNI Screen) was developed to assess this range of functions and others (e.g., affect expression and perception of affect). It permits rapid but reliable assessment of a range of higher cerebral functions, allowing an experienced clinician to make judgments about the nature and severity of neuropsychological disturbances and, therefore, to assess possible changes in a patient's clinical status over time.

Previous research with this instrument has documented its reliability[17] and its concurrent and construct validity.[15] This study extends these findings by analyzing how patients with probable senile dementia of the Alzheimer's type (DAT) perform on the BNI Screen.

Methods

Subjects

Twenty patients who met the criteria of DAT according to the DSM-III-R criteria and who met the criteria of probable Alzheimer's disease according to the NINCDS/ADRDA served as subjects.[12] These extensive criteria are reviewed here briefly. Specifically, they exclude patients judged to have dementia on the basis of a variety of etiologies other than probable Alzheimer's disease (e.g., B-12 deficiency, pernicious anemia, hypothyroidism). Patients with other significant neurological problems such as Parkinson's disease, epilepsy, a past head trauma, stroke, or an inflammatory or infectious brain disease were also excluded from the study. Patients were further

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excluded on the basis of delirium, generalized anxiety disorder, phobic disorder, schizophrenia, delusional disorder, psychoactive substance abuse, or alcohol dependence as defined by DSM-III-R criteria.

Of these 20 patients, 19 were studied as a part of two ongoing drug trials, but they were assessed before they were randomized to any treatment. Thus, the BNI Screen was used as part of their baseline clinical assessment, which included other neurological and neuropsychological procedures. One subject, who was not involved in these clinical trials, met all the above criteria.

In addition, 20 age- and sex-matched controls who had no history of neurological or psychiatric problems were studied. These patients were recruited from the volunteer services at St. Joseph's Hospital and Medical Center, from a retirement area in the Sun City suburb of Phoenix, Arizona, and from family members who brought patients for clinical evaluation. All control subjects were functionally independent and were not referred for clinical evaluation. In all cases, informed consent was obtained.

There were 9 males and 11 females in both groups. The mean age of the Alzheimer's patients was 73.9 years, and the mean age of the control subjects was 72.3 years (Table 1). The Alzheimer's patients had an average of 11.34 years of education compared to 13.30 years for the control subjects. All of the patients were right-handed.

Procedures

All patients and control subjects were administered the BNI Screen by a board-certified clinical neuropsychologist or postdoctoral fellow in clinical neuropsychology under supervision. Overall, the test required about 15 to 20 minutes to administer. A few severely demented patients required more time to complete the test but never more than 30 minutes.

All Alzheimer's patients were also administered the Mini Mental State Examination (MMSE), according to Folstein, Folstein, and McHugh,[5] to provide a common reference for the degree of impaired cognitive functioning seen in this group of patients. Control subjects, however, were not administered the MMSE.

Table 1. Demographic Comparison of Alzheimer's Patients and Control Subjects

	Age (years)			Education (years)		
	Mean	SD	Range	Mean	SD	Range
Alzheimer's patients	73.9	5.75	56-83	11.34	3.63	5-18
Control subjects	72.3	6.16	53-84	13.30	2.43	9-18

Materials

The BNI Screen consists of a manual, stimulus booklet, record form, and standard stopwatch. Details of the text materials, scoring, and selection rationale are described elsewhere.[14] Briefly, the BNI Screen consists of a variety of tasks. The patient has to follow auditory commands, name objects, repeat sentences, write to dictation and copy, spell, perform arithmetic tasks, remember three words with distraction, and learn four number-symbol associations. Visuospatial problem-solving skills, visual sequencing skills, pattern recognition skills, the ability to generate affect in one's tone of voice upon command, and the ability to perceive facial affect are also sampled. Patients are also asked to predict whether they will be able to recall three words with distraction. A total score is calculated from these items and the highest possible score is 50. Seven subtest scores are also calculated: speech and language functions, visuospatial functions, attention and concentration functions, memory functions, orientation functions, affect perception and expressive functions, and awareness of memory skills.

The MMSE, which was given to Alzheimer's patients, is well known and described elsewhere.[5]

Results

Alzheimer's Patients Versus Controls

There was no significant difference in the age of the Alzheimer's patients and the age of the control subjects ($t = 0.85$, $df = 38$, $p = .40$). The mean difference in the number of years of education between the two groups approached significance ($t = 2.00$, $df = 38$, $p = .053$). Comparison of the control subjects with the Alzheimer's patients by analyses of covariance (ANCOVA) statistically accounted for the educational differences.[5] Patients obtained a total score of 29.15 on the BNI Screen total score compared to 44.2 by controls (Table 2). The difference was highly significant ($t = 9.34$; $df = 38$; $p = <.001$). Figure 1 plots the *t*-score values obtained for Alzheimer's and control subjects using a larger normative data base (Prigatano, Amin, Rosenstein, unpublished data). Two normal controls fell below 1 standard deviation of expected values. Eighteen of the Alzheimer's patients performed at least 2 standard deviations below normal value.

The Alzheimer's patients also performed significantly worse than controls on virtually every subtest (Table 2), again reflecting the variety of cognitive impairments this group demonstrates. When education was held constant via ANCOVA, all of the statistical results reported in Table 2 were replicated at the $p=.01$ level or higher (Table 3).

Sensitivity and Specificity of the BNI Screen in the Elderly

One goal of any cognitive screening instrument is the correct classification of patients. This can be

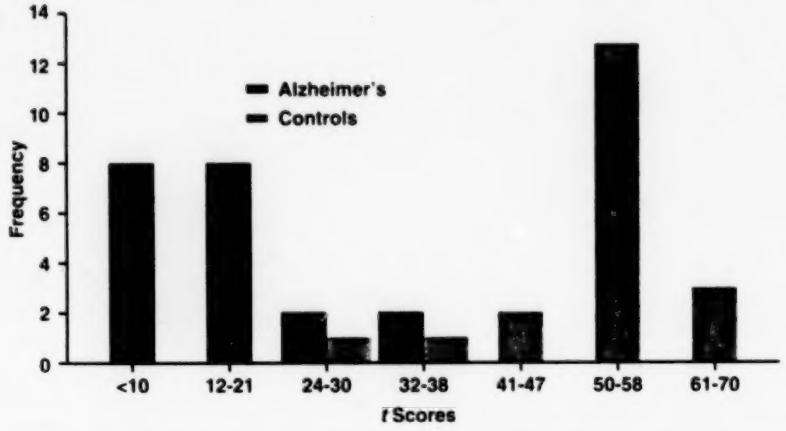

Figure 1. Distribution of BNI total score by groups converted to *t*-score values.

Table 2. Total and Subscores on the BNI Screen

Scale	Alzheimer's		Controls		*t* Value*
	Mean	sd	Mean	sd	
Speech/Language	11.60	(3.70)	14.75	(0.55)	3.70
Orientation	1.55	(8.26)	2.80	(0.41)	6.06
Attention/Concentration	1.00	(0.65)	2.35	(0.75)	6.11
Visuospatial	3.40	(1.64)	5.65	(1.27)	4.86
Memory	0.30	(0.66)	5.40	(1.70)	12.53
Affect	2.35	(1.09)	3.60	(0.60)	4.50
BNI Total	29.15	(6.22)	44.20	(3.64)	9.34

*$df = 38$, $p < .001$.

Table 3. Removal of Education Covariate

Scale	Adjusted Sums of Squares					
	Mean	*df*	Error	*df*	*F* Value	*p* <
Speech/Language	90.66	1	265.90	37	12.61	.01
Orientation	10.90	1	14.28	37	28.25	.01
Attention/Concentration	16.25	1	18.54	37	32.42	.01
Visuospatial	38.55	1	77.66	37	18.37	.01
Memory	229.26	1	62.57	37	135.57	.01
Affect	12.84	1	29.02	37	16.37	.01
Awareness	3.57	1	4.50	37	29.36	.01
BNI Total	1937.84	1	969.09	37	73.99	.01

difficult because normal elderly individuals demonstrate some decline in memory and speed of information processing.[1] Most of the control subjects had a BNI Screen total score of 40 or higher (mean score, 44.20; sd = 3.64, Fig. 2). When a cut-off score of 40 was used, all Alzheimer's patients were properly classified and only two control subjects were misclassified. The sensitivity of the test was therefore 100% and its specificity was 90% (Table 4). When a cut-off score of 43 was used (the expected mean value for normal subjects between 60 and 70 years old), the estimate of the sensitivity was 100% and the estimate of specificity was 80%.

BNI Screen versus MMSE

The mean BNI Screen total score for Alzheimer's patients was 29.15 (range, 17-30), and the mean MMSE total score was 19.55 (range, 5-24). The correlation obtained between the BNI Screen total score and the MMSE total score was 0.546, which was statistically reliable at the .05 level ($df = 19$). This score accounted for about 30% of the variance shared between the two groups.

Clinical Utility of the BNI Screen in the Assessment of Probable Alzheimer's Patients

Alzheimer's patients were notably impaired on the BNI Screen compared to the control subjects. Does, however, this particular instrument provide clinical information not obtained by such tests as the MMSE? Table 5 compares the Alzheimer's patients with controls on various items used to calculate the BNI Screen total score and subtest scores.

No Alzheimer's patient (or control subject) failed the visual object recognition task, a test of visual object agnosia. The rarity of this condition would predict this finding. All control subjects obtained perfect or almost perfect scores on speech fluency, auditory comprehension, naming, repetition, reading, and writing despite age or level of education. None of the control subjects exhibited evidence of constructional dyspraxia or a problem in copying a simple pattern. In contrast, 20% of the Alzheimer's patients showed difficulties in free speech. Thirty percent demonstrated naming difficulties as well as difficulties with auditory comprehension and repetition. Twenty-five percent had difficulties writing and 55% had difficulties with spelling.

As would be expected, 85% of the Alzheimer's patients were disoriented while 85% of the control

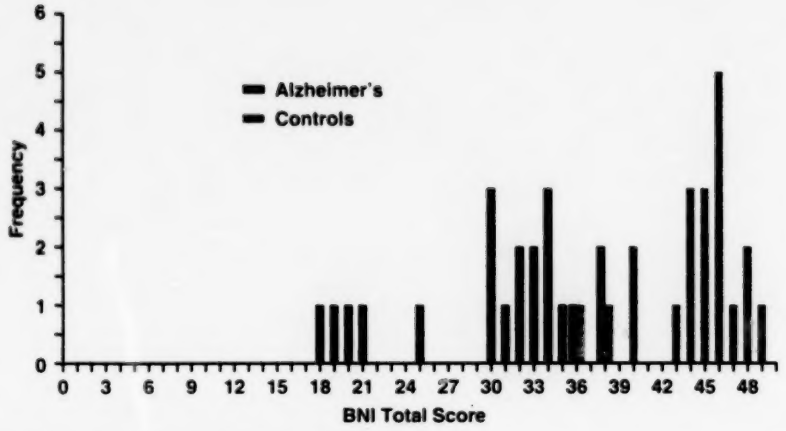

Figure 2. Distribution of BNI total score by groups.

Table 4. Sensitivity and Specificity of the BNI Screen

BNI Total	Alzheimer's		Controls		Row Total
39 or less	(a)	20	(b)	2	22
40 or greater	(c)	0	(d)	18	18
Column Total		20		20	40

Sensitivity =a/(a+c) = 20/20 = 100%. Specificity = d/(b+d) = 18/20 = 90%. False negative ratio = b/(a+b) = 2/22 = 9%. False positive ratio = c/(c+d) = 0/18 = 0%.

Table 5. Percentages of Subjects Receiving Full Credit on Items from the BNI Screen

	Alzheimer's	Controls
Speech	80	100
Comprehension	70	95
Naming	70	100
Visual Object Recognition	100	100
Repetition	70	95
Reading	95	100
Writing	75	100
Spelling	45	95
Orientation	15	85
Constructional Praxis	65	100
Arithmetic	10	65
Digits	5	65
Visual Scanning	15	50
Visual Sequencing	0	30
Pattern Copying	35	100
Pattern Recognition	5	20
Number-Symbol Association	0	45
Affect	15	65
Delayed Recall	0	70
Awareness	0	65

Table 6. Frequency of Disorientation and Capacity to Learn Number-Symbol Associations in Alzheimer's Patients and Normal Elderly Controls

	Number-Symbol Learning Task Score	
	0 or 1	2, 3, or 4
Alzheimer's Patients		
Oriented	2	1
Disoriented	17	0
Normal Elderly Controls		
Oriented	4	14
Disoriented	0	2

subjects obtained perfect orientation scores (i.e., they were given full credit for identifying the year, month, date, day of the week, city, and name of the building they were in when tested). In contrast to the control subjects, Alzheimer's patients showed clear signs of constructional dyspraxia.

Normal, healthy, elderly control subjects had difficulty on some items. For example, on a pattern recognition task only 20% of the control subjects passed this item compared to 5% of the Alzheimer's patients. Only 45% of the control subjects could recall all four number-symbol associations, one of the more difficult learning and memory items on the BNI Screen.

However, control subjects seldom, if ever, had poor scores on both the number-symbol association and orientation tasks. In contrast, 17 of 20 Alzheimer's patients were disoriented to time, place, or both (Table 6). None of these patients could learn more than one of four number-symbol associations. In contrast, two of the 20 control subjects had trouble with time orientation but demonstrated substantial learning on the number-symbol task.

Seventy percent of control subjects could recall three words with distraction; none of the Alzheimer's patients could perform this task.

When asked to write and add the three numbers, "10", "832," and "963," some Alzheimer's patients had difficulty transcribing the number, 832, from dictation. They tended to write numbers such as 8032 or 80032, apparently having difficulty conceptualizing how to write the number, 32, in relationship to the concept of 800. None of the control subjects showed this difficulty compared to 7 of the 20 Alzheimer's patients. These 7 Alzheimer's patients were then compared to the 13 Alzheimer's patients who had no trouble with this task. There was no difference in their mean age, education, or performance on the memory subtest of the BNI Screen. However, their BNI Screen total scores were reliably different as were their MMSE scores. The mean BNI Screen totals for those who correctly transcribed the numbers was 31.31 compared to 25.14 for those who incorrectly transcribed the number ($t = 2.35$, $df = 18$, $p = .03$). The mean MMSE scores were 21.08 for those who wrote the number correctly and 16.71 for those who wrote it incorrectly ($t = 2.38$, $df = 18$, $p = .03$).

Discussion

The present investigation documents that the BNI Screen may be useful in the clinical assessment of patients who meet research criteria for DAT. Patients suspected of Alzheimer's dementia performed at a level that indicated severe impairment of higher cerebral functioning for their age group. The pattern of their performance showed a variety of cognitive and related deficits, as would be expected in this patient group.[18]

The BNI Screen provides not only a single total score, but subtest scores that evaluate language function, visuospatial functions, facial affect perception, and the ability to generate affect in one's tone of voice, as well as memory and awareness scores. These subtests yield predictable differences in patients with right versus left hemisphere disease.[15] This feature of the BNI Screen is a substantial improvement over the MMSE, which has been criticized for not adequately assessing functions that are often impaired after right cerebral hemisphere dysfunction.[1]

The BNI Screen total score correlated significantly with the MMSE total score, but as noted, the correlation accounted for only about 30% of the test variance. Inspection of the items that constitute the BNI Screen compared to those on the MMSE suggests that the BNI Screen, in fact, samples a wider variety of abilities than the MMSE (e.g., visual scanning, affect perception, awareness of deficit). A recent report[3] has noted the statistical and clinical limitations of the MMSE.

The sensitivity and specificity figures obtained using the BNI Screen are acceptable given the small sample used in this study. Based on a cut-off score of 40, the sensitivity and specificity were quite high. A cut-off score of 43 (a cut-off score suggested in the standardization of this test sample) revealed excellent sensitivity and moderately good specificity. Eighty percent of the normal control subjects were correctly classified with this criterion. This is an improvement over other screening instruments that often report specificity figures in the range of 50%, especially when evaluating individuals who have limited education and who are 60 years of age or older.[1] The control subjects in this study, however, were typically well educated. If their mean educational level had been lower, the specificity estimates might have well been attenuated.[15]

Besides its quantitative measures, the BNI Screen has qualitative features that may be especially helpful to clinicians. For example, 7 of the 20 Alzheimer's patients had difficulty writing the number 832 to dictation. Grafman et al.[7] also report such a deficit in a 66-year-old male with DAT. They suggest that more "syntactically complex" numbers were not written correctly. Butters[3] recently suggested that this deficit may reflect a break-down in semantic memory in certain Alzheimer's patients. Obtaining such qualitative information not only helps evaluate a given patient, but it provides information that might also be useful for research.

Our data also provide potential clinical guidelines in assessing older individuals suspected of Alzheimer's disease. Disorientation for time and memory impairments is common in this group of patients.[9] Elderly control subjects at times did not know the exact date. Yet, these individuals could recall at least two of four number-symbol associations on the BNI Screen (Table 6). In contrast, Alzheimer's patients who were disoriented for time were unable to demonstrate this level of learning on a new task. The careful clinical assessment of these two dimensions (i.e., orientation to time and capacity to learn new information) may be especially helpful in the early assessment of Alzheimer's disease.

The poor performance of the Alzheimer's patients on the recall with distraction task underscores the importance of carefully assessing memory impairment in Alzheimer's patients. The finding is also consistent with reports that 20% to 25% of normal individuals older than 70 years forget one or more of three items with distraction,[9] while Alzheimer's patients show more severe memory impairment.[3]

Age influences the total score on the BNI Screen. In a sample of 70 normal controls, 60 years of age or older, the mean value obtained during the standardization of this test was slightly more than 43 points (sd = 3.40) (Prigatano, Amin, Rosenstein, unpublished data). Thus, as a group, the Alzheimer's patients in the present study were often three standard deviations below expected normal values. This level of performance reflects severe restriction of higher cerebral functions and is compatible with the diagnosis of DAT. In contrast, the control subjects tended to perform in the expected range for their age.

The present study provides encouraging quantitative and qualitative data regarding the use of the BNI Screen in assessing patients suspected of DAT. Further research, however, will be needed to document the clinical utility and cost effectiveness of this neuropsychological instrument.

[3] Butters N. Presidential Address at the National Academy of Neuropsychology. Phoenix, AZ, October 29, 1993

[9] Kaszniak AW. Neuropsychological differentiation of cognitive changes associated with dementia versus normal aging. A workshop presented at the Annual Meeting of the National Academy of Neuropsychology. Phoenix, Az., October 28, 1993

[15] *Ibid*

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